Mid-Coast Implementation Ready TMDL

Sediment

Technical Working Group

Wednesday, March 20, 2013

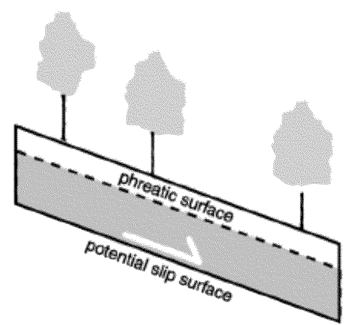
Newport, Oregon

Shallow Landslide Prediction Methods

- Factor of Safety Approach
- Geomorphic Approach

Factor of Safety Approach

$$FS = \frac{\text{Resisting Stress}}{\text{Driving Stress}}$$



$$FS = \frac{c_\mathrm{r} + c_\mathrm{s} + [q_\mathrm{t} + \gamma_\mathrm{m} D + (\gamma_\mathrm{sat} - \gamma_\mathrm{w} - \gamma_\mathrm{m}) H_\mathrm{w} D]\cos^2\beta \tan\phi}{[q_\mathrm{t} + \gamma_\mathrm{m} D + (\gamma_\mathrm{sat} - \gamma_\mathrm{m}) H_\mathrm{w} D]\sin\beta\cos\beta}$$

c_r	=	cohesive strength contributed by tree roots (force/area)
c_s	=	cohesive strength of soil (force/area)
q_t	=	uniform surcharge due to weight of vegetation (force/area)
γ_m	=	unit weight of moist soil above phreatic surface (weight/volume)
γ_{sat}	=	unit weight of saturated soil below phreatic surface (weight/volume)
γ_w	=	unit weight of water (9810 N/m^3 of 62.4 lb/ft^3)
D	=	thickness of soil above slip surface (length)
H_w	=	height of phreatic surface above slip surface, normalized relative to soil thickness (dimensionless)
β	=	slope angle (degrees)
ϕ	=	angle of internal friction (degrees)

FS < 1 = Failure

Source: Haneberg 2004 – A Rational Probabilistic Method for Spatially Distributed Landslide Hazard Assessment

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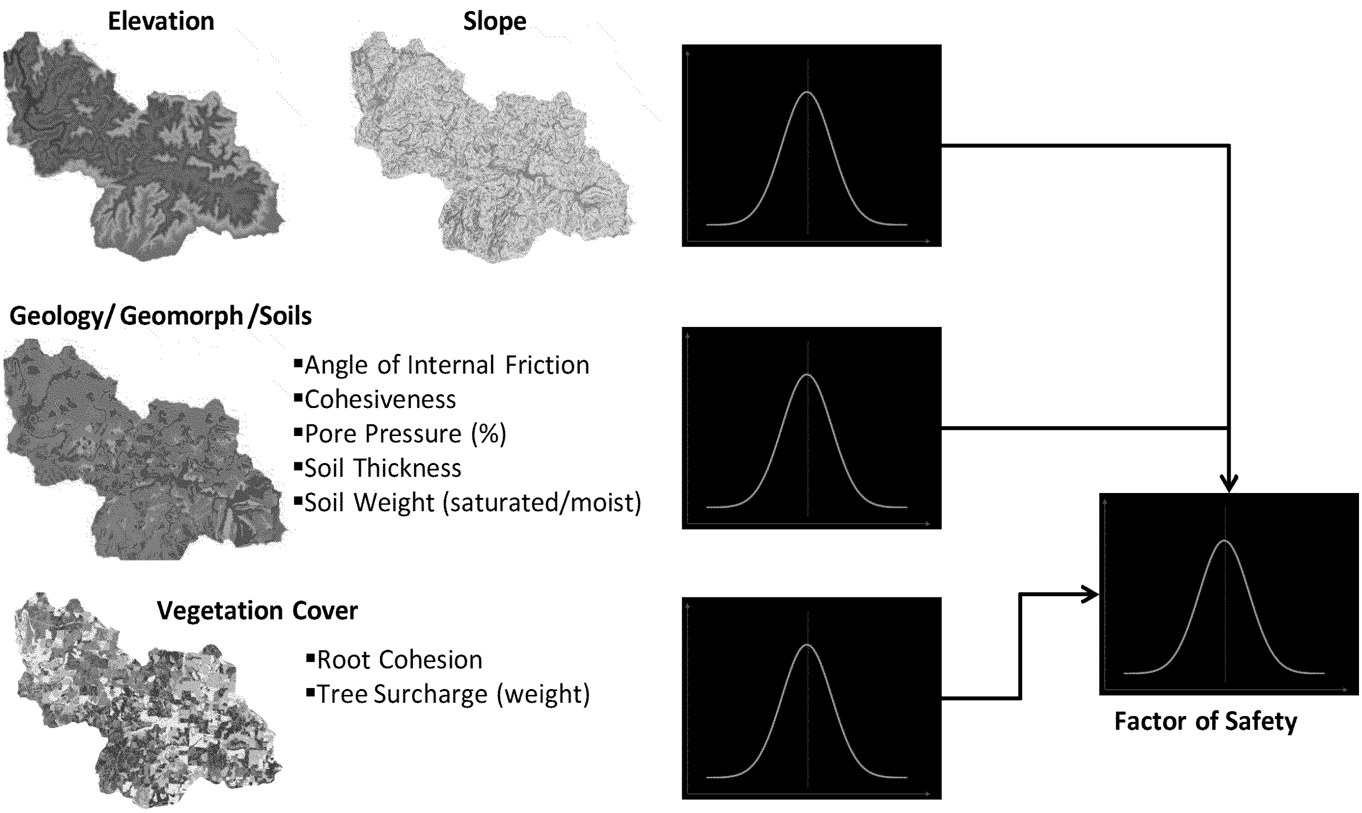
PISA-m

- Probabilistic Infinite Slope Analysis that is map based
- Developed by Bill Haneberg (Haneberg 2004)
- Based on USFS model LISA and DLISA
- Incorporates parameter uncertainty
- Predicts probability of slope failure using factor of safety
- Availability of input data can be limited

Source: Haneberg 2004 – A Rational Probabilistic Method for Spatially Distributed Landslide Hazard Assessment

PISA-m



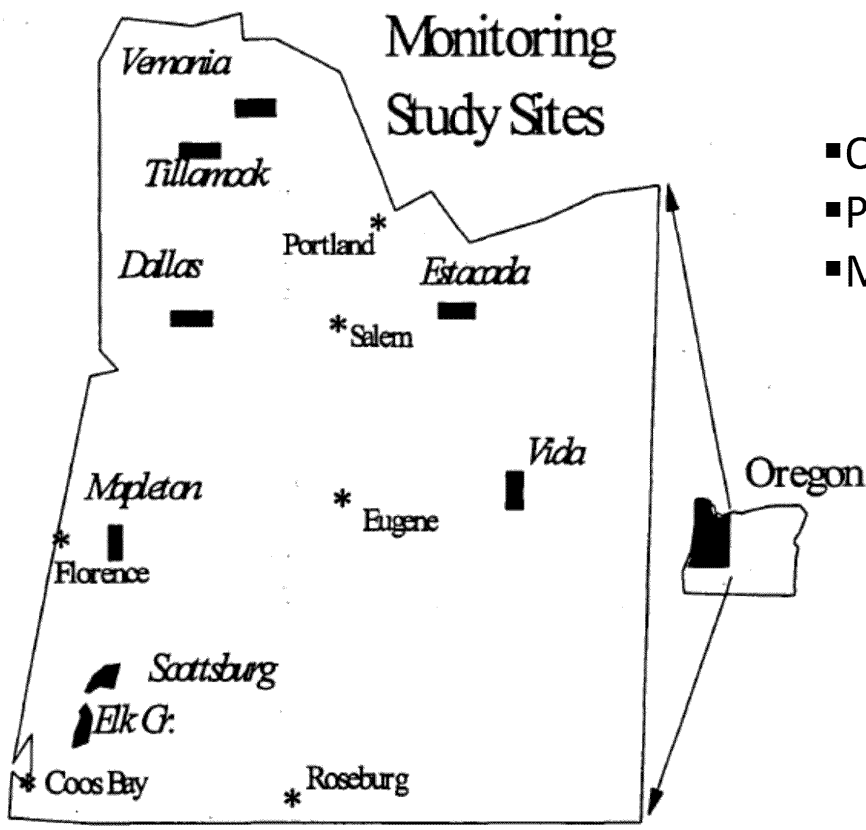
Source: Haneberg 2004 – A Rational Probabilistic Method for Spatially Distributed Landslide Hazard Assessment

Geomorphic Approach

- Principal assumption:
  All factors being equal, soil properties and landform morphology are the primary indicators of shallow landslide susceptibility.
- Identify important indicators and classify into susceptibility categories.
- Tends to over predict susceptibility but good approach when coupled with a ground based review.

Shallow Landslide Analysis

1. Calibration
   - Field Inventory
   - Identify Indicators
     - Slope, Landform, Lithology
     - Precipitation, Vegetation
2. Susceptibility Mapping
3. Stream Delivery



- ODF Study
- Post 1996 Storms
- Many Study Sites

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Inventory Data

- Landslide Type / Origin
- Landform Type
- Slope (pre slide)
- Volume and Size
- Transport distance
- Vegetation Age
- Soil Characteristics (bedrock, soil type)
- Many other things

Inventory Data Summary

	Erodible (Elk Creek, Scottsburg, Mapleton)	Resistant (Tillamook, Vida, Dallas, Estacada)
Total # Landslides (Does not include road related)	326	135
Study Area (sq/mile)	22	20.2
Landslide Density (#/sq mile	14.8	6.7

Landform Type	**Erodible**	**Resistant**
Concave (cv)	133	33
Uniform (un)	122	74
Convex (vx)	38	23
Irregular (ir)	22	1
Other / not classified (ot/NA)	11	4

Origin	**Erodible**	**Resistant**
In Channel/Gully	1	3
Channel Adjacent	84	64
Upslope	241	68

Note: Excludes road related landslides

Inventory Areas

Site	Robison et al 1999 Lithology Classification	DEQ Lithology Classification	Use
Big Elk Creek	-	Erodible	Validation
North Fork Siuslaw	-		
Elk Creek	Red Zone Tyee		Calibration
Mapleton			
Scottsburg			
Tillamook	Red Zone Igneous	Resistant	
Vida			
Dallas	Random Stratified		
Estacada			
Vernonia			

LiDAR available

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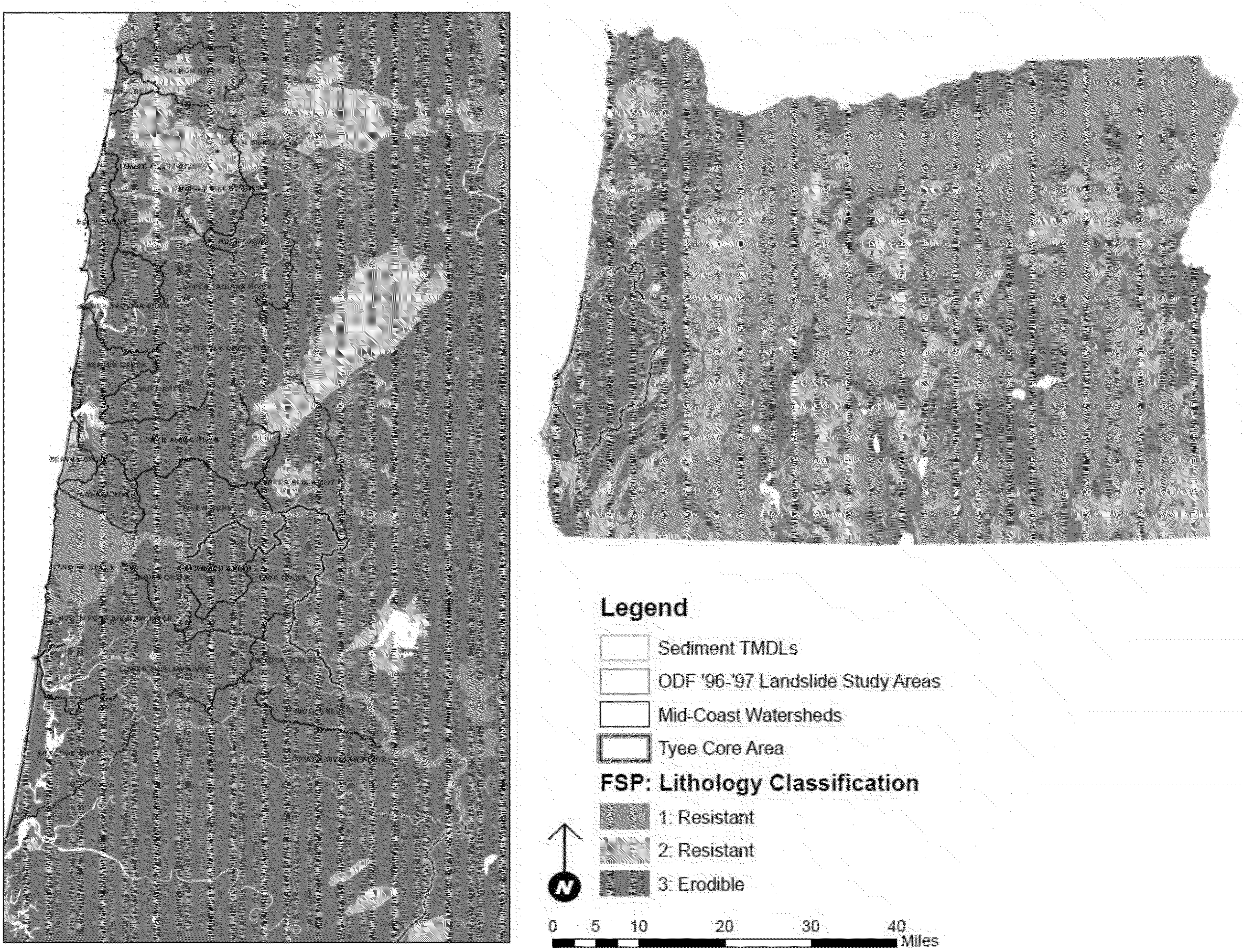
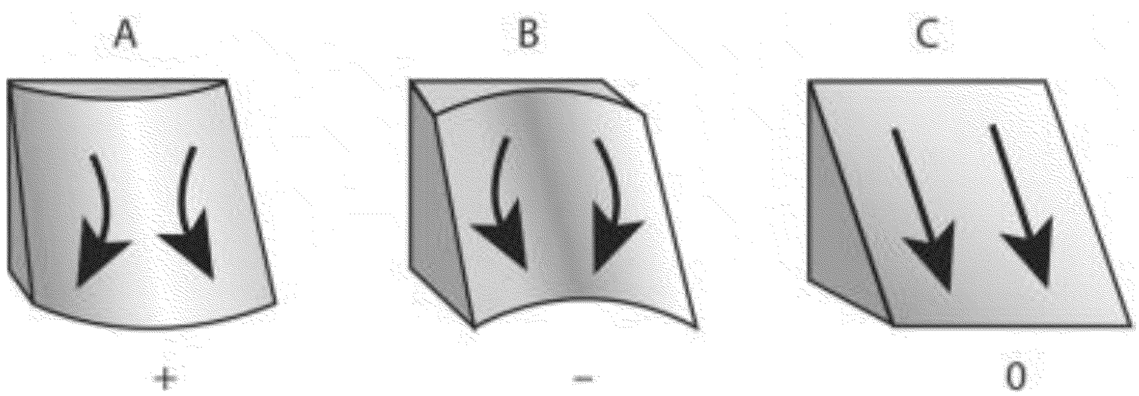

Legend
Sediment TMDLs
ODF '96-'97 Landslide Study Areas
Mid-Coast Watersheds
Tyee Core Area
FSP: Lithology Classification
1: Resistant
2: Resistant
3: Erodible
N
0
5
10
20
30
40
Miles

Planview Landform Types



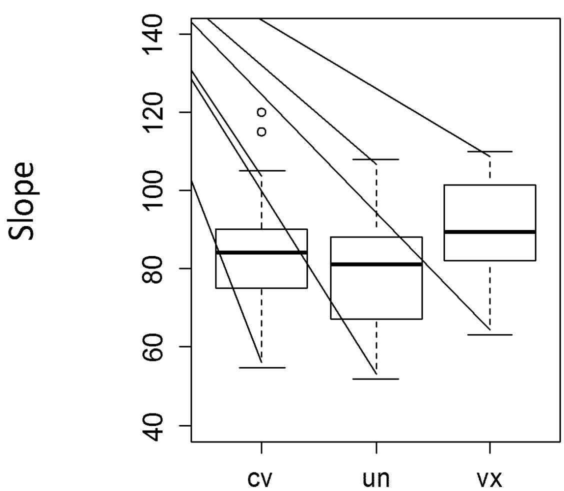
Convex (vx) Concave (cv) Uniform (un)

Water tends to concentrate here

Image source: Kimerling et al 2011. *Map Use: Reading, Analysis, Interpretation, seventh edition*

Non-Road Landslides Stratified by Landform Type

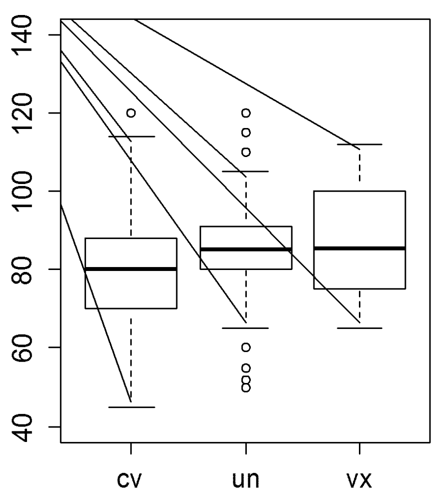
Resistant Sites



No significant difference between landforms
ANOVA ($p > 0.1$) $p = 0.92$

Legend
cv = concave   un = uniform
vx = convex   ir = irregular

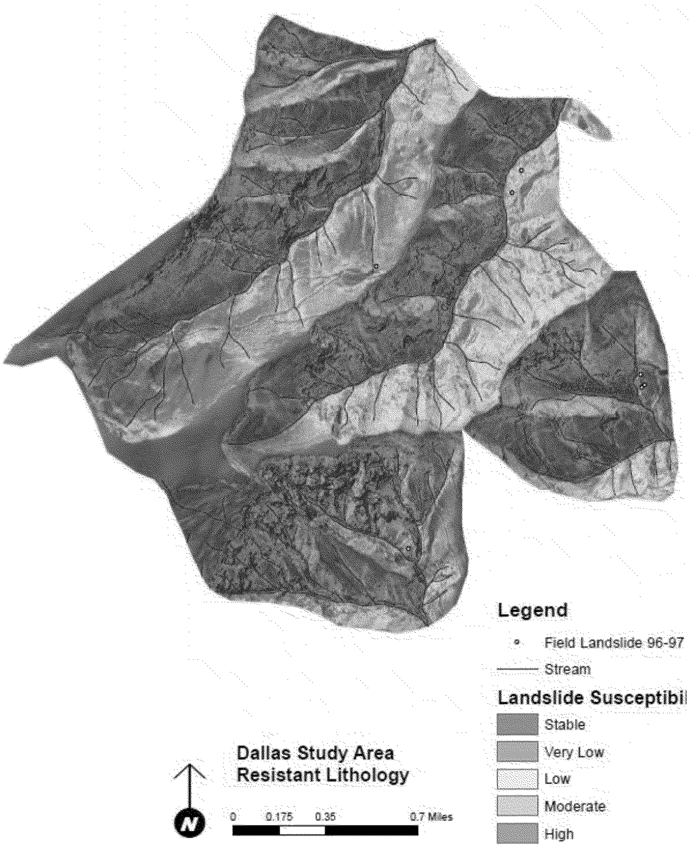
Erodible Sites

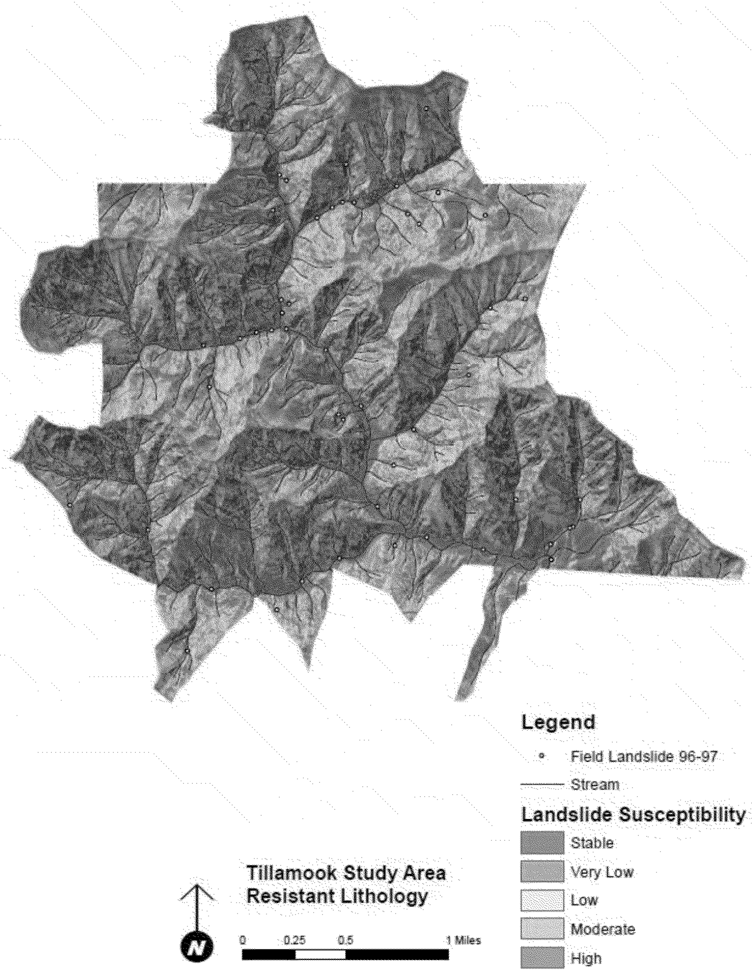


Concave is significantly different
from other landforms
ANOVA/Tukey ($p < 0.10$) $p = 0.001$

Landform / Slope Classification

		Percent Slope Class			Percent of Landscape	
		Erodible Lithologies		**Resistant Lithologies**	**Erodible Lithologies**	**Resistant Lithologies**
Susceptibility Classification	Percentile of Landslides	Convex & Uniform	Concave	All Landform Types		
Stable	0%	0% -49%	0% -44%	0% -49%	30%	24%
Very Low	0% - 9%	50% -64%	45% -59%	50% -64%	15%	21%
Low	10%-24%	65% -79%	60% -69%	65% -74%	18%	18%
Moderate	25% - 49%	80% -89%	70% -79%	75% -84%	14%	16%
High	50%-100%	90% ≤	80% ≤	85% ≤	23%	21%





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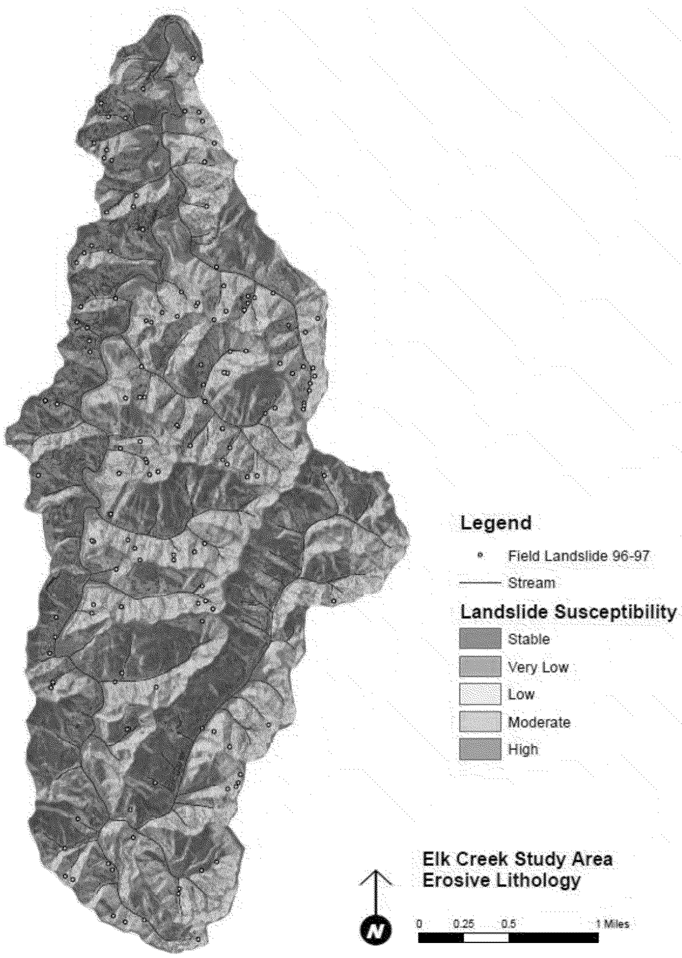
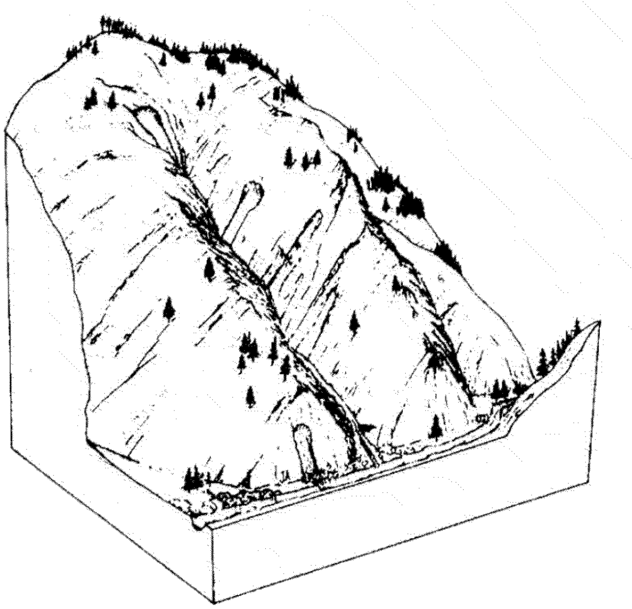
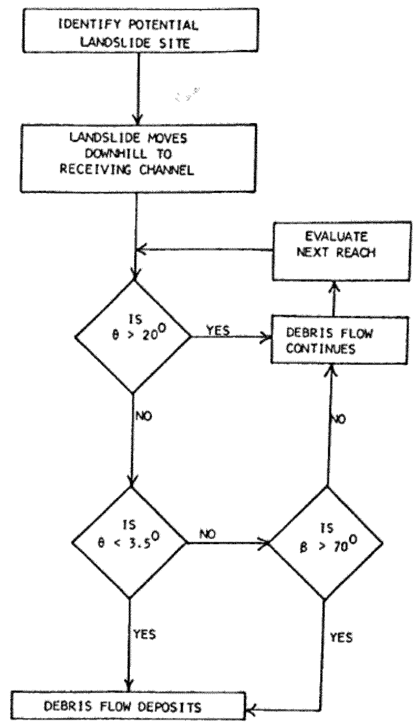

Legend
Field Landslide 96-97
Stream
Landslide Susceptibility
Stable
Very Low
Low
Moderate
High
Elk Creek Study Area
Erosive Lithology
N
0 0.25 0.5 1 Miles


Legend
Field Landslide 96-97
Stream
Landslide Susceptibility
Stable
Very Low
Low
Moderate
High
Scottsburg Study Area
Erosive Lithology
N
0 0.225 0.45 0.9 Miles

Stream Delivery

- Slope / Slope Length
- Channel Junction Angle





Source: Benda and Cundy 1990. Predicting deposition of debris flows in mountain channels.

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